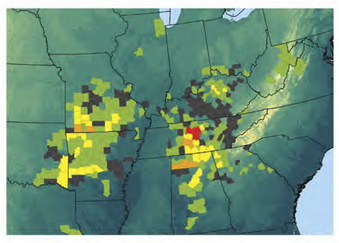
Missouri Botanical Garden

North America

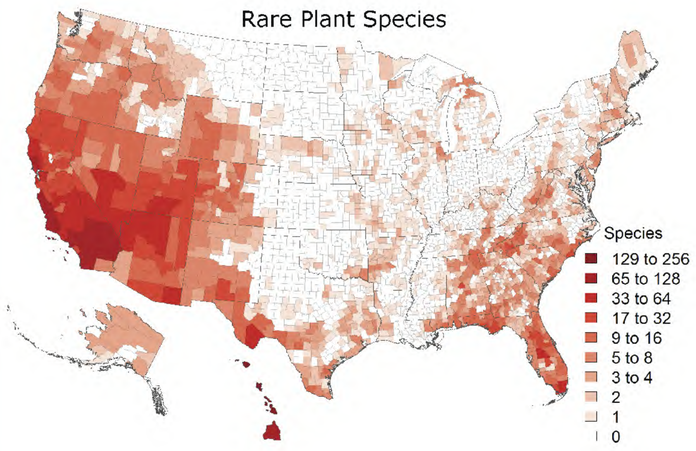
Introduction: The Garden's North American Program focuses on understanding and conserving biodiversity throughout North America. Through innovative research, Garden scientists are developing methods to conserve plant diversity at scales ranging from genes to plant populations to entire ecosystems. Ongoing floristics research improves our understanding of plant diversity in North America by discovering and classifying plants and studying their distributions and relationships over space and time. The multifaceted conservation programs in the Garden's Center for Conservation and Sustainable Development (CCSD) focus on developing innovative methods to conserve threatened plant species and restore degraded ecosystems, understanding patterns of genetic variation in threatened plants, and conducting basic research to understand how global change affects biological diversity. Results and discoveries from the research of Garden scientists provide the foundation for conservation actions designed to halt the loss of plant diversity.

Building Capacity: Training the next generation of biodiversity and conservation scientists is a core component of the Garden's North American conservation and research programs. The capacity-building programs take a multi-tiered approach to training people of different educational backgrounds—from professional botanists and conservationists to university students to citizen scientists. A prestigious fellowship program administered by the CCSD provides opportunities for young career professionals to work with the scientific staff at the Garden and local universities. Each year, the National Science Foundation-funded Research Experiences for Undergraduates (REU) program provides research training for up to ten students from across the country. CCSD scientists also host annual training workshops for students from the local universities and give workshops to St. Louis community groups on invasive species management.

Global Change



For every pound of human biomass on the planet, there are one million pounds of "stuff" we have manipulated in unnatural ways: roads, cars, houses, electronics, and much more. The Global Change Conservation Lab at the Missouri Botanical Garden seeks to understand the effects of this massive conversion of nature and thereby improve Earth's life support system. For example, we have analyzed the threats to all of the rare and threatened plant in the United States. This analysis uncovered many wide-ranging threats (invasive species, climate change, agriculture, and development), but also identified other unexpected yet pervasive threats to plants (outdoor recreation). We also develop scenario-based analyses to understand the effects of climate change on rare and important species. For example, we examined the effect of climate change on the physical size of big bluestem (*Andropogon gerardii*), a dominant grass of Midwestern prairies commonly used in grassland restoration and a key component of the region's multibillion dollar livestock industry. Using statistical computer models we founds that big bluestem could decline in stature by up to 60% by the 2080s. We also developed a system based on current threats and climate change to prioritize 80 rare species in the region surrounding the Garden for conservation seed banking. The Global Change Conservation Lab also organizes regular training workshops to teach students and professionals the most current climate-species modeling techniques.



Caption: (Top) The number of plant species impacted by development in the region (red = more, green = fewer). Garden scientists are studying the spatial patterns of threats to prioritize species and geographic areas for conservation (Bottom) Garden scientists recently mapped the distribution of rare and threatened plant species in the United States. Data used to generate the maps originate from botanists collecting, discovering, and classifying plants in North America for more than a century.

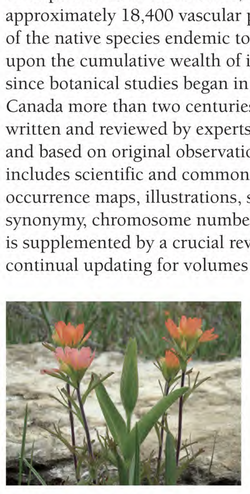
Conservation Genetics

The Conservation Genetics Lab at the Missouri Botanical Garden uses genetic approaches to understand more about the biology of threatened and endangered plant species in order to help conserve them more effectively. Current projects in the lab involving North American plant species include: (1) using genetic data to understand the ecology and reproductive biology of *Asclepias meadii*, *Polygala lewtonii*, and *Euphorbia rosescens*, all of which are threatened or endangered, (2) measuring how genetic variation is structured across the landscape in three federally threatened Midwestern plant species, *Physaria filiformis*, *Geocarpon minimum*, and *Leavenworthia exigua* var. *laciniata*, to formulate strategies to ensure that their genetic diversity is effectively conserved, (3) using genetic analysis of ex situ collections of the federally endangered Florida endemic *Ziziphus celata* to aid in reintroduction and restoration efforts, (4) clarifying patterns of evolutionary history and species boundaries in a federally endangered, taxonomically questionable species, *Lilaeopsis schaffneriana*, to ensure that conservation efforts are being devoted to a unique species that is deserving of protection, (5) understanding how rare plants in the genus *Leavenworthia* respond to environmental stress, and (6) understanding the origins of the endemic flora of the Tennessee cedar glades.

Caption: (Top left) *Physaria filiformis* (Missouri bladderpod) is known only from Missouri and Arkansas and listed as federally threatened on the Endangered Species Act. Genetic studies have helped prioritize populations for habitat protection and for the Garden's seed bank. (Above) *Asclepias meadii* (Mead's milkweed) is a long-lived perennial herb endemic to tallgrass prairies in the Midwest. Genetic studies are informing management efforts to reverse genetic bottlenecks in this species that resulted from habitat loss, fragmentation, and land-use changes over the past century.

Floras

The *Flora of North America* presents for the first time a synoptic account of the vascular plants and bryophytes of North America north of Mexico. Projected to be published in 30 volumes, the *Flora* includes approximately 18,400 vascular plants, with about 60% of the native species endemic to the *Flora* area. Building upon the cumulative wealth of information acquired since botanical studies began in the United States and Canada more than two centuries ago, descriptions are written and reviewed by experts from the systematic botanical community worldwide and based on original observations of living and herbarium specimens. Each treatment includes scientific and common names, taxonomic descriptions, identification keys, occurrence maps, illustrations, summaries of habitat and geographic ranges, pertinent synonymy, chromosome numbers, phenology, ethnobotanical uses, and toxicity. The *Flora* is supplemented by a crucial review of the literature. In addition, published volumes and continual updating for volumes in production are included at floranorthamerica.org.



The *Flora of Missouri* project, a joint effort between the Missouri Department of Conservation and the Missouri Botanical Garden Press, was a revision of *Steyermark's Flora of Missouri*. This project culminated in a three-volume revision of the vascular plants of Missouri, covering a total of 2,739 species, of which 1,933 are native and 806 are introduced species. Current changes in the classification of families and genera based on molecular data have resulted in significant differences compared to the published volumes. These changes and the active botanical community in Missouri have added an average of nine species to the flora each year since the first publication, necessitating a new phase of the project. Recent molecular studies may also compel the description of novel species or reinstatement of species formerly relegated to synonymy for the flora. The current project will provide a field guide format of the flora with updated family and generic classifications, with all new species to the flora included. This will be done in combination with a dynamic, interactive, and illustrated web format (tropicos.org/Project/MO) based on vouchered herbarium specimens that allows for continual updating.

Caption: (Top right) *Astragalus bibullatus* (Pyne's ground-plum) is native perennial member of the legume family. The Garden is spearheading a long-term research and recovery program to ensure the continued survival of this critically imperiled species in the wild. (Bottom left) *Castilleja coccinea* (Indian paintbrush) is a stunning native wildflower of prairies, meadows, and glades throughout Missouri and the eastern United States. This species is a hemiparasite that seeks out the roots of nearby grasses and wildflowers for nutrition.

Restoration

Effective and science-driven ecological restoration practices are urgently needed to assist the recovery of damaged ecosystems and address global losses of biodiversity. In North America, the Garden works to advance ecological restoration through scientific research, large-scale model restoration projects, and capacity building through education and outreach. Research by the CCSD informs the restoration of rare plant communities and critical habitat for globally imperiled plant species. The restoration of diverse natural communities at the Shaw Nature Reserve serves as a model project for the Ecological Restoration Alliance (ERA), a global consortium of botanical gardens actively engaged in ecological restoration. At the Nature Reserve, more than 35 years of land stewardship and intensive restoration efforts have produced a biodiverse mosaic of prairies, woodlands, glades, and wetlands. This rich landscape provides a living laboratory for ecological research, as exemplified by an 11-year study documenting dramatic and persistent increases in native plant diversity in degraded woodlands after repeated prescribed fires and removal of fire-intolerant eastern red cedar. In collaboration with CCSD, restoration recently commenced in a 60-acre woodland at the Nature Reserve that had become infested with bush honeysuckle (*Lonicera maackii*) and other invasive species. This project incorporates workshops to share best-practices for invasive species control and woodland restoration with private landowners and others land stewards. A joint effort of CCSD, the Nature Reserve, and the Garden's horticulture division developed a new mapping application to document restoration activities such as prescribed fire, invasive species control, and sowing of native seed to enhance diversity.

Caption: (Top left) The Garden has been involved in several projects over the years to reintroduce globally threatened plant species into protected areas. These projects use seed from the Garden's seed bank for restoration source material and rely upon the Garden's horticultural expertise for propagation. (Top right) Volunteers remove the invasive bush honeysuckle (*Lonicera mackii*) from woodlands at the Shaw Nature Reserve. Exotic species are major threats to biodiversity in the region, requiring continual management to prevent their regrowth. (Bottom) Staff executing a prescribed fire in restored woodlands at the Garden's Shaw Nature Reserve. Fire is a key process in maintaining native biodiversity and reducing the spread of invasive species in the Nature Reserve's natural areas.

Species Conservation

Scientists estimate that nearly a third of all native plant species known in the United States are at risk of extinction. To safeguard them, the species conservation program blends field and lab research with on-the-ground conservation activities (seed-banking, reintroduction, and habitat restoration) to develop science-based solutions for improving the long-term survival of threatened plant species in their native ecosystems. Research focuses primarily on grasslands and woodlands in the south-central United States, a region rich with rare and endemic plant species of conservation concern. Garden scientists are conducting experiments in regional natural areas and at the Shaw Nature Reserve to determine the best-management practices for threatened plant species, including the optimal timing of prescribed fire management and techniques for enhancing the genetic and demographic viability of declining populations. In the past decade, several globally threatened species have been reintroduced into natural areas in Missouri and surrounding states, using genetic material in long-term storage in the Garden's seed bank. Garden scientists are involved in developing and refining guidelines for the reintroduction of threatened plants now being used by conservation practitioners across the globe.

Seed banks are a form of *ex situ* conservation that involves conserving plants as frozen seed to provide a safety net for species in case they become extinct in the wild, or before their habitats can be protected or restored. As a participating member in the Center for Plant Conservation (CPC), a coordinated network of 40 botanical gardens and arboreta in the United States and Canada, one focus of the Garden's seed-banking efforts includes globally threatened or vulnerable plant species in south-central United States. Using standardized protocols, we curate over 1,700 seed bank accessions representing 70 globally rare species in the region as part of CPC's National Collection of Endangered Plants. A second goal involves banking seed from every native plant species known in the Missouri flora. Seeds from approximately 20% of Missouri's flora (442 species) are already banked, and efforts continue to bank seed from prairies to bottomland forests, with the recently completed *Flora of Missouri* serving as a comprehensive resource for species identification and pinpointing native populations for collection.

Caption: (Left) Garden scientist monitoring a wild population of an endangered plant. Monitoring data informs management decisions needed to prevent a species from going extinct in the wild. (Center) Collecting seed of the federally threatened *Geocarpon minimum* (Tinytim) for long-term storage in the Garden's conservation seed bank. *Geocarpon* is one of many native species being safeguarded by the Garden for the Center for Plant Conservation's National Collection of Endangered Plants. (Right) Takings cuttings of *Neviusia alabamensis* (Alabama snow wreath), an imperiled native shrub and member of the Rose family. Now extinct in Missouri, the Garden is building a genetically diverse living collection from remaining populations of this species in surrounding states. The collections can be used for future research and recovery efforts.

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Science and Conservation at the Missouri Botanical Garden

With operations in over 35 countries around the globe, the Missouri Botanical Garden collaborates with local institutions wherever Garden botanists conduct research and field work, providing technical expertise, assistance with fundraising, and better communication with the worldwide scientific community.

The research division consists of 50 Ph.D. botanists assisted by 144 support staff and 20 graduate students. Studies concentrate on the plants of Meso- and South America, sub-Saharan Africa, Madagascar, China, and North America.

Individual Garden scientists are specialists in the plants of particular regions, in the systematics and evaluation of major plant families, and in the interactions between plants and people.

The Garden serves as the headquarters for several major collaborative publications, such as *Flora of North America* and *Flora Mesoamericana.*

For more information, visit
www.mobot.org/plantscience

Edgar Denison (1904–1993). Truly a man for all seasons, German-born Edgar Denison was an engineer by trade, but also a naturalist, amateur botanist, artist, conservationist, and citizen scientist. He immigrated to St. Louis as a young man and immersed himself in the study of plants and their habitat by hiking across the landscapes of his newly adopted state. The result of those trips was his seminal work *Missouri Wildflowers* (1972), featuring his own illustrations. He shared his knowledge of native plant life by leading groups on countless nature hikes in Missouri. Denison was widely considered an environmental leader in the St. Louis area. He was active with the Missouri Botanical Garden providing articles for the Garden's *Bulletin*, training volunteers, and giving tours of the Shaw Nature Reserve. He was a co-founder of the Missouri Native Plant Society and is honored as a member of the Missouri Department of Conservation Hall of Fame.

Silene regia (royal catchfly) is a tallgrass prairie wildflower native to the Midwest, found mainly in Missouri, rendered here by Edgar Denison.

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